DEVELOPMENT OF WIRELESS RTD TEMPERATURE MEASUREMENT USING DECADE BOX

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Electronics)"

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ABSTRACT

The project proposed is to develop GUI (Graphical User Interface) application using visual basic. Wireless system is interfacing between camputer-based and instrument for temperature measurement to measure temperature where the data from measurement process can be directly use for other purpose, such as calculation and data monitoring. This project will involve designing the GUI application to monitor temperature changes using visual basic 2008. Manual method in temperature measurement are measure and calculate the data manually. The system is developed to facilitate for taking the data directly from the computer. This project will use the wireless RTD system as a sensor to interface between computer and temperature instrument such as temperature transmitter. Wireless RTD system that will use is called Zig-bee technology. Zig-bee technology are self configuring short range network and low cost. Decade box will use as a testing and calibration to create a resistance or capacitance with a specific value by using a combination of the rotary decade switches. For this project, the expected outcome is GUI application will monitor temperature changes through Zigbee wireless system. This project will make the wireless process instrumentation and wireless terminal technology for instrumentation directly leads to efficient process and equipment validation in current technology.

ABSTRAK

Projek yang dicadangkan adalah untuk membangunkan GUI *(Graphical User Interface)* aplikasi yang menggunakan *Visual Basis*. Sistem komunikasi tanpa wayar antara komputer dan instrumen bagi pengukuran suhu untuk mengukur suhu di mana data dari proses pengukuran dapat terus digunakan untuk tujuan lain, seperti pengiraan dan data pemantauan. Projek ini akan melibatkan merancang aplikasi GUI untuk memantau perubahan suhu menggunakan *Visual Basic 2008*. Kaedah manual dalam pengukuran suhu mengukur dan menghitung data secara manual. Sistem ini dibangunkan untuk memudahkan untuk mengambil data secara terus dari komputer. Projek ini akan menggunakan sistem tanpa wayar RTD sebagai pengesan untuk perhubungan komunikasi antara komputer dan alat pemancar suhu seperti suhu. Sistem tanpa wayar RTD yang akan menggunakan teknologi yang dikenali sebagai Zigbee. Teknologi Zigbee ini adalah untuk menyediakan rangkaian jarak pendek dan kos yang rendah. *Decade Box* akan digunakan sebagai ujian dan kalibrasi untuk mencipta rintangan atau kapasitor dengan nilai tertentu dengan menggunakan kombinasi dari suis dekad pemutaran. Untuk projek ini, hasil yang dijangkakan adalah aplikasi GUI akan memantau perubahan suhu melalui sistem tanpa wayar Zigbee. Projek ini akan memastikan instrumentasi proses tanpa wayar, dan teknologi terminal tanpa wayar untuk instrumentasi secara langsung ke arah proses yang cekap dan validasi peralatan teknologi yang terkini.

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ADC	Analog- Digital Converter
DC	Direct Current
GUI	Graphical User Interface
GPIB	General-Purpose Interface Bus
IDE	Integarted Developement Environment
LCD	Liquid Crystal Display
LRV	Lower Range Value
PWM	Pulse Width Modulate
RTD	Resistance Temperature Detector
URV	Upper Range Value
VB	Visual Basic

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In the industrial, temperature is one of the most frequently measured parameters in process system. The electrical thermometer is used, to sense and control the process temperatures. Regular calibration of these thermometers is critical to ensure consistent quality of product manufactured, as well as providing regulatory compliance for some industries. Industrial process temperature measurements are more critical than ever. Attempts to improve the quality or efficiency of industrial processes has led to a rapid increase in the number of temperature sensors installed in these systems as well as increased requirements for temperature measurement. The project is generally based on using temperature sensor devices for collecting and monitoring data from the plant station and transferring the measured temperature parameters to the computer.

In this project, GUI (Graphical User Interface) application will be developed using visual basic. This software is developed and responsible for establishing and manages communications between PC and wireless system. The wireless system is used to interface between instrument and computer. From this project, Decade Box represents RTD (Resistance Temperature Detector) is use as a temperature sensor to detect temperature change. The input will convert into current signal between 4 – 20 mA.

1.2 PROBLEM STATEMENT

In the industrial, temperature measurement is one of the most frequently measured parameters in process system. Resistance Temperature detectors have become industry standards for simple and cost-effective temperature measurement. However, achieving such measurement in an accurate, reliable and cost-effective manner is a challenging problem. If station is far away from the workplace, it is difficult to collect and monitor temperature changes. It wastes time to take and check temperature reading at plant station. They also need to analysis and monitor the data everyday or weekly to make sure the instrument in good condition.

1.3 OBJECTIVE OF THE RESEARCH

The objectives of the project are:

1. To develop GUI (Graphical User Interface) application using visual basic.

   Visual Basic is use as a main programming language. Data will transfer to PC and data will display in GUI application.

2. To interface between instrument and software application using the wireless system.

   Zig-Bee Wireless system is use to interface between instrument and computer. This system will use PIC controller as a converter that is convert analog signal from temperature transmitter to digital signal before data is transmit.

3. To monitor the temperature measurement directly by software application.

   Temperature measurement is the way that can be used to measure temperature where data from measurement process can be directly use for other purpose, such as analysis and monitoring data.

1.4 SCOPE OF THE PROJECT

The scopes of this project are:

1. Develop GUI (Graphical User Interface) application using Visual Basic in software application.

   Easy to collect and monitor the data from temperature transmitter by developed GUI application and programming using Visual Basic 2008 Edition software.

2. Zig-bee wireless technology will use to interface between computer and temperature instrument such as temperature transmitter, HART communicator, etc.

   In industry plant, wireless technology can help user and ease for user to collect data and doing observation of temperature only in controller room. So, user do not need to go the plant station and take readings manually.

3. Decade Box represents the RTD (Resistance Temperature Detector) is use as input device to detect temperature changes.

   This device is suitable for precision measurement applications and the calibration of laboratory or workplace equipment.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will explain about the literature review part that taking from journals or articles which related with the project.

2.2 Smart RTD Temperature sensor with a prototype IEEE 1451.8 Internet Interfere

This research was conducted by Darold Wobschall and Wai sing Poh from Department of Electrical Engineering, University at Buffalo, Amherst. The Resistance Temperature Detector (RTD) was a sensor which can benefit greatly by smart transducer techniques that was, digital signal processing and digital transmission of data. The RTD was a stable sensor capable of resolving temperature changes to at least 0.001 °C over a temperature range of -200 °C to 400 °C continuously and over 600 °C for shorter times.

Thus, the readout must been capable of about 2 pm resolution while most analog readouts, such as the 4-20 mA ament loop, are have errors in the range of 100 to 500 ppm A microcomputer with a built-in high-resolution analog-todigital converter *(ADC)* is used here to acquire the signal [1].

Research by three partners from delphi corporation, Resistive Temperature device (RTD) high temperature sensor was developed for exhaust gas temperature measurement. Extensive modeling and optimization was used to supplement testing in development. The sensor was developed to be capable of withstanding harsh environments (-40 to 1000 degrees Celcius), typical of engine applications, including poisons, while maintaining high accuracy (< 0.5% drift after 500 hrs of aging at 950 degree Celcius) [2].

Resistance Temperature Detector (RTD) is basically a temperature sensitive resistor. It is a positive temperature coefficient device, which means that the resistance increases with temperature. The resistance of the metal is increasing with temperature. The resistive property of the metal is called its resistivity. The resistive property defines length and cross sectional area required to fabricate an RTD of a given value. The resistance is proportional to length and inversely proportional to the cross sectional area that see in the Equation (2.1):

$$R = (r \times L)/A \qquad (2.1)$$

Where R = Resistance (ohms)
r = Resistivity (ohms)
L = Length
A = Cross sectional area

The devices criterion for selecting a material to make an RTD is that the material must be malleable so that it can be formed into small wires. It must have a repeatable and stable slope or curve. The material should also be a resistant to corrosion and low cost. It is preferred that the material have a linear resistance verses temperature slope.

Some of the common RTD materials are Platinum with a temperature coefficient of 0.00385 - 0.003923 Ω/Ω/°C and practical temperature range of -452 to +1100°F (-269 to +593°C). The platinum RTD has the best accuracy and stability among the common RTD materials. The resistance versus temperature curve is fairly linear and the temperature range is the widest of the common RTD materials. Platinum has a very high resistivity, which means that only a small quantity of platinum is required to fabricate a sensor and making platinum cost competitive with other RTD materials. Platinum is the only RTD commonly available with a thin film element style. As a Primary uses, Platinum is the primary choice for most industrial, commercial, laboratory and other critical RTD temperature measurements. Copper, nickel and nickel iron are also commonly used RTD materials. Platinum RTDs are manufactured with two distinct types or temperature coefficients (μ). The temperature coefficient (μ) is the slope of the platinum RTD between 0°C to 100°C [3].

This is calculated by the following formula in the Equation (2.2):

$$\mu = (R_{100} - R_0)/ (100 \text{ X } R_0) \qquad (2.2)$$

Where μ= Temperature Coefficient (W/W/°C)

R_{100} = RTD resistance at 100°C

R_0 = RTD resistance at 0°C

2.2.1 Measurement Circuit

RTDs are three measurement techniques. RTDs were inherently 2-wire devices. A 2-wire measurement has the RTD as one leg of a resistance bridge circuit with a DC source supplying excitation current to the RTD. Voltage across the bridge is measured and resistance calculated using formula see in the Equation (2.3):

$$R = V/I \tag{2.3}$$

The calculated result includes the resistance of the test leads as well as the RTD resistance, which significantly reduces accuracy. Figure 2.1 shows the 2-wire RTD measurement is the least expensive. This has led to the development of more accurate 3-wire and 4-wire measurement techniques.

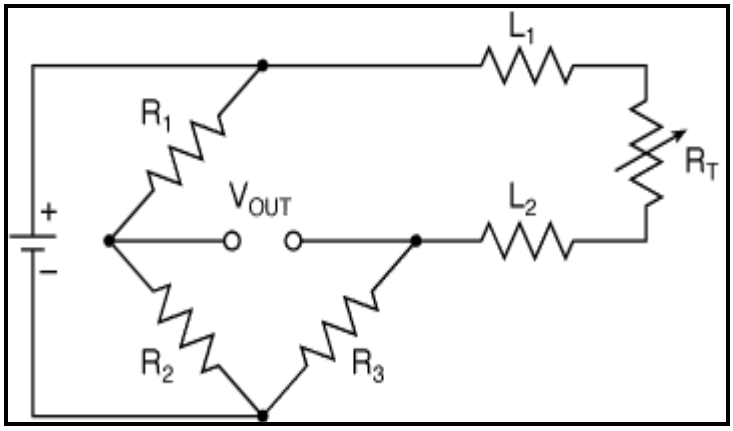

Figure 2.1: 2 - wire RTD [5]

The 3-wire technique was useful when there is significant distance between the sensor and the instrument. A bridge circuit was utilized with an instrument that has a high-impedance DC op-amp input circuit. The third wire was connected between one

end of the RTD and the HI SENSE terminal of the instrument. These insures that little or no current flows through that lead, so its resistance is not much of a factor in the measurement. By using equal wire lengths and diameters for the other two leads, their voltage drops cancel out. Figure 2.2 shows the 3-wire circuit provides better accuracy, especially for long lead runs [3], [5].

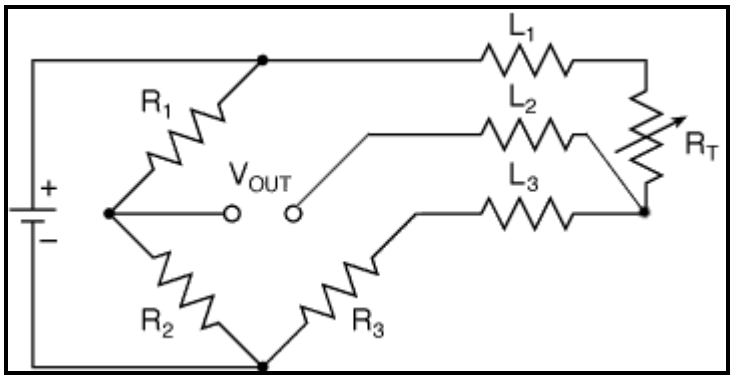

Figure 2.2: 3-wire RTD [5]

The 4-wire, or Kelvin, measurement uses one pair of leads to supply excitation current to the RTD and a second set of instrument leads to measure voltage directly across the RTD. The 4-wire measurements minimize lead voltage drop and provide the greatest accuracy is combined with an instrument having high input impedance. These is technique of choice in research labs and other sensitive applications. Figure 2.3 shows the 4-wire circuit has the best accuracy.